



ALLIED VEHICLE TESTING PUBLICATIONS

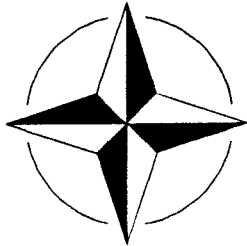
TRIAL SERIES 04

PROTECTION

| AVTP | TEST TITLE |
|---------|--------------------------------|
| 04 - 10 | Conventional Attack |
| 04 - 20 | Nuclear Attack |
| 04 - 30 | Biological and Chemical Attack |
| 04 - 40 | Active Radar |

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VEHICLE TESTING
PUBLICATION

AVTP : 04
EDITION NO.:
DATE : SEPT. 1991



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PROTECTION

TEST TITLE : CONVENTIONAL ATTACK
NUCLEAR ATTACK
BIOLOGICAL AND CHEMICAL ATTACK
ACTIVE RADAR

No action on TRIAL SERIES "PROTECTION" was taken because of lack of expertise.

Indication:

There is working group of the Four Nation MOU on Test & Evaluation, dated 05.12.1983, dealing with NBC-Protection.

For "Conventional Attack" US has and issued The following TOPS :

2-2-617 Armored Vehicle Vulnerability to
Conventional Weapons

2-2-620 Resistance of Armored Vehicles to
severe Shock

2-2-715 Protection by Armored Vehicles against
kinetic Energy Projectiles

2-2-722 Fragment Penetration Test of Armor

Since the above TOPs need updating any updated TOPs can be submitted as AVTP candidate in accordance with the administrative informations.



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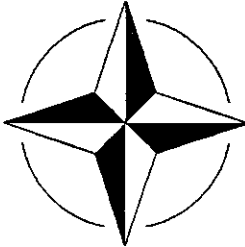
TRIAL SERIES 05

SECURITY FROM DETECTION

| AVTP | TEST TITLE |
|---------|---|
| 05 - 10 | Visual |
| 05 - 20 | Hot Surfaces / Infra Red |
| 05 - 30 | Measurement of the Radar Cross Section (RCS) |
| 05 - 40 | Radar |
| 05 - 50 | Magnetic Signature |
| 05 - 60 | Acoustic |

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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : VISUAL

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 05-10

FOR COMPLIANCE
WITH : -

ABSTRACT : This Document describes procedures
for the determination of security
from detection in the visible
range of the vehicles.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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deviate from a provision of this AVTP due to
constraints such as available facilities, national
regulations, instrumentation accuracies, etc., the
test methods used will be described in the report.
However, such deviation may cause nonacceptance of
test data by other nations.

FOR THE MILITARY AGENCY OF STANDARDIZATION

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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

| Identification of Change or Amendment and Reg.No.(if any) and date | Date Entered | NATO Effective Date | By whom entered Signature, Rank, Grade or Rate, Name of Command |
|---|-----------------|---------------------------|--|
| | | | |

*) See Reservations Overleaf

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Trial Series: VEHICLE BUILD

Test Title : VISUAL

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. TEST CONDITIONS
- 3.1 Vehicles
- 3.2 Test Site
- 3.3 Weather Conditions
- 3.4 Special Conditions
- 3.5 Observers
4. TEST PROCEDURE
- 4.1 Detection in Daylight
- 4.2 Detection at Night
- 4.3 Exhaust Effects
- 4.4 Dust Cloud
5. DATA REQUIRED
6. PRESENTATION OF DATA
- 6.1 Detection in Daylight
- 6.2 Detection at Night
- 6.3 Exhaust Effects
- 6.4 Dust Cloud

ANNEX A: Reference Grid

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1. SCOPE

a. This document describes a method of evaluating security from detection in the visible range of the vehicles under selected conditions, with direct vision and without additional aids to vision or concealment.

b. The sighting procedure consists of the three following successive phases (abbreviation: D.R.I.):

Detection (D): presence of a feature in the Scene that indicates a target of potential military interest is in the area under observation.

Recognition (R): differentiation between various categories of targets or objects (e.g. difference between a tank and a troop transporter).

Identification (I): the identity of a target may be given within a given category.

c. A vehicle's security from detection is evaluated on the basis of the following factors:

Detection in daylight: this test establishes the visual D.R.I. ranges against typical backgrounds, with the vehicle stationary and then coming closer in an oblique line with respect to the observation.

Detection at night: this test establishes the visual D.R.I. ranges with the vehicle either moving or stationary, under selected night operating conditions.

Exhaust effects: this test determines the extent to which the effects of the vehicle's exhaust system can betray its position.

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Dust cloud: this test determines the extent of the dust cloud raised by the vehicle when travelling in dry conditions at various speeds over selected surfaces.

2. FACILITIES AND INSTRUMENTATION

2.1 FACILITIES

- a. Trial sites representative of theatres of operation.
- b. Reference vehicle, presented in a visual configuration identical to that of the test vehicle.

2.2 INSTRUMENTATION

DEVICES FOR MEASUREMENT OF:

PERMISSIBLE ERROR OF MEASUREMENT*

| | |
|------------------------------------|--|
| a. Visibility distance | 5 % from 50 m to 2 km 10 % from 2 km to 20 km |
| b. Time | 1 s |
| c. Distance | 5 % |
| d. Ambient Temperature | 1 °C |
| e. Atmospheric Pressure (optional) | 2 hPa |
| f. Relative Humidity | 3 % of full scale |
| g. Smoke Density | 100 ppm |
| h. Background Luminance | 5 % |

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement in 20.

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Miscellaneous

- i. Radio link
- j. Photo and video camera

3. REQUIRED TEST CONDITIONS

3.1 VEHICLES

Ensure that:

- a. the vehicle is clean
- b. the side lights and blackout equipment are working.
- c. the vehicle is in combat order.

3.2 TEST SITE

Select positions representative of tactical stops, except under special conditions.

3.3 WEATHER CONDITIONS

- a. The visibility range should be more than 3000 m.
- b. Special conditions applicable to certain tests will be specified in these tests.
- c. Tests can be carried out for every season and the climatic conditions should be representative of each of them as far as possible.

3.4 SPECIAL CONDITIONS

No vehicles other than those taking part in the test are allowed in the test area.

3.5 OBSERVERS

- a. Observers must not suffer from any vision defects. Each

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observer should be tested before and after each set of trials and the results recorded.

b. In order to achieve representative results, there should be as many observers as possible, at least thirty.

c. Observers should be chosen as being representative of an average sample. A description will be provided of each observer, for instance speciality, experience, age.

4. TEST PROCEDURE

4.1 DETECTION IN DAYLIGHT

4.1.1 Static deployment

1. Aim of test

- To compare D.R.I. time of the test vehicle with that of the reference vehicle.

- The comparison will be made by associating two kinds of tests:

- . a terrain evaluation,
- . a photo-simulation evaluation

- The photo simulation evaluation aims at completing the information derived from the terrain evaluation in particular by making it possible to estimate the detection distances of the test and reference vehicles.

2. Conditions of terrain evaluation

The vehicles will be observed alternately in identical sites and positions so as to arrive as closely as possible at equivalent lighting conditions and limit the effects of environment:

- a different group of observers will be used for each observation cycle of either vehicle,

- each observation is carried out separately without any visual or sound contacts between the observers in a group,

- there must be the same number of observers for each test

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3. Photo-simulation conditions

- The trial is carried out in two phases:
 - . ground photos for each of the observation phases:
 - phase 1: observation of the reference vehicle
 - phase 2: observation of the test vehicle.
 - . observers are shown the photos in a suitable room.
- This test is carried out in the room.

The photos are shown to the observers in the following sequence:

- . Observer 1: (1) Photos of the first phase
(2) Photos of the second phase
- . Observer 2: (1) Photos of the second phase
2) Photos of the first phase
- . etc.

This enables two parameters to be noted for a given vehicle.

- . detection time
- . detection distance

4. Vehicle position

The vehicle must offer a maximum profile to the line of observation.

The vehicle can also be presented in other positions (e.g. front view) if these are likely to be characteristic.

5. Observation ranges

Observation ranges will be as follows:

- . 2500 m
- . 2000 m
- . 1500 m
- . 1000 m

These distances are given as a guideline and can be changed to meet the dimensional characteristics of the test vehicle.

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6. Observation sector

The observation sector should be of approximately 90 deg.

7. Photographic conditions

- Photos will be taken during the field evaluation, taking account of the instructions previously given with regard to: vehicles, locations, meteorological and special conditions and observers.

- Photographs. The camera settings (f number and speed) should be set correctly and recorded to ensure a correct exposure.

- The characteristics of the photos will be as follows:

- . colour slides - size 24 x 36 mm
- . ground observations:
 - distance : 300 m
 - focal distance : 28, 35, 50 and 65 mm
- . principal axis for taking photos: from South to North.
- . photos to be taken for each observation phase of each vehicle concerned.

8. Conduct of tests

8.1 Field evaluation

- The general test conditions are noted on the test record:

- . range,
- . test vehicle,
- . weather,
- . visibility.

- The observers are called, one after the other, and are given the following information:

- . the limits of the test sector,
- . maximum observation time,

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- . the observer must not know whether the vehicle he is looking for is the test or the reference vehicle.
- Commence observation: start stop watch:
- . note detection time,
- . ask the observer to give place of detection,
- . if the detection is wrong, do not note the time but tick the appropriate square: the observation continues,
- . note time taken for recognition,
- . if an error is made, note the answer: the observation continues,
- . note time for identification,
- . if an error is made, note the answer: the observation continues,
- . the observation is completed after the maximum time allowed.

8.2 Photo-simulation evaluation

- Detection time.

The following information is given to each observer:

- . observation time: 90 s,
- . only one answer is allowed,
- . the squared grid (see ANNEX A) enables the observer to locate the observed vehicle.

On the photos shown:

- . the stop watch is set going,
- . as soon as the observer says "seen", the watch is stopped,
- . time is rounded off to the higher value (every 5 seconds),
- . the observer shows on the grid the location of the target he has detected,

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- . the data record is filled in, taking account of erroneous detections and possible non-detections.

- Detection range

For a given observation phase, the photos taken at the various focal distances indicated in paragraph 4.1.1.7 are successively projected during 20 seconds.

The following indications are given to each observer:

- . the time for each observation: 20 seconds,
- . only one answer is allowed,
- . the square grid to enable him to indicate the vehicle observed (see ANNEX A).

The photos are shown: as soon as the observer detects the target the photo number is recorded.

4.1.2 Moving vehicles.

1. Principle

To compare the visual perceptions recorded when the trial vehicle and reference vehicle are both moving at the same time.

2. Conditions

The comparative test is conducted with the reference vehicle and the test vehicle following the same route at a distance of approximately one thousand metres from each other.

The movement of the vehicles is either continuous or in consecutive jumps using the cover available (selected with respect to the terrain).

The vehicle silhouette must not be outlined against the horizon.

Vehicle movements take place in sectors previously selected on tracks or roads.

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3. Observation distance

- Vehicles will be observed at about one and a half times the average visual detection distance for the test vehicle in a static position.
- This distance will then be increased or decreased depending on whether confirmed perception of the vehicle has been obtained or not.

4. Sequence of operations

- The data record is completed:
 - . distance,
 - . vehicles observed,
 - . weather,
 - . visibility.
- The observation begins:
 - . record the time for the various phases, Detection, Recognition and Identification.
 - . note any characteristic details which have been drawn to the attention of the observer (bright paint...).

4.2 DETECTION AT NIGHT

4.2.1 In a static position

1. Principle

Same as paragraph 4.1.1.1.

2. Conditions

Same as paragraph 4.1.1.2.

3. Backgrounds

- Vehicle not darkened but outlined against a background which rises above it.
- Vehicle in tree shade.

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4. Vehicle position

The vehicle should show its maximum silhouette in the axis of observation.

The vehicle can also be shown in another position (front view for instance) if this is probably characteristic.

5. Observation distance

The observation distance will be determined with respect to the lighting conditions.

This distance will then be increased or decreased depending on whether a confirmed perception of the vehicle has been obtained or not.

6. Observation sector

The observation sector must be of the order of 90°.

7. Special conditions

The following should be taken into account:

- Vehicle lighting:

- . no normal lighting on,
- . lighting on - minimum lighting in silent routine.

- Ambient lighting:

- . no moon, clear sky,
- . no moon, cloudy sky,
- . full moon, clear sky,
- . full moon, cloudy sky.

8. Sequence of operations:

- The data record is completed.

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- The observation begins:

- . record the time taken for the D.R.I. phases,
- . note any characteristic details which have attracted the observer's attention.

4.2.2 Moving

1. Principle

Same as paragraph 4.1.2.1.

2. Conditions

Same as paragraph 4.1.2.2.

3. Range of observation

Vehicle will be observed at about one and a half times the average visual detection distance for the test vehicle in a static position.

This distance will then be increased or decreased depending on whether confirmed perception of the vehicle has been obtained or not.

4. Special conditions

The following should be taken into account:

- Vehicle light:
 - . working lights - minimum lighting for silent watch period.
- Background lighting:
 - . no moon, clear sky,
 - . no moon, overcast,
 - . full moon, clear sky,
 - . full moon, overcast.

5. Conduct of test:

Same as paragraph 4.2.1.8.

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4.3 EXHAUST EFFECTS

a. During the preceding trials, study the influence of the vehicle's exhaust system on the three target acquisition phases:

1. flame emission,
2. smoke emission,
3. formation of icy fog ¹⁾

b. A comparative test with the reference vehicle can be carried out under the following conditions:

- . operation at the same time and in a similar manner as the test vehicle,
- . in static tests, the distance between vehicles should be about 50 m,
- . when moving, the distances between vehicles should be about 100 m.

c) Measure the density of smoke emission, using a smoke meter.

4.4 DUST CLOUD

a. During the preceding trials, study the influence on the three target acquisition phases of the presence of a dust cloud raised when the vehicle is moving over suitable ground (dirt track...).

b. A comparative test with the reference vehicle can be carried out under the following conditions:

- . operation at the same time as the test vehicle,
- . at the same speed,
- . over the same ground.

¹⁾ Icy fog is formed when hot exhaust gases come into contact with very cold air. This phenomenon only occurs in very cold climates and its extent depends on the temperature of the exhaust gases and also on that of the surrounding air. It can be observed when testing is done in winter and only facilitates daytime detection.

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c. The following can be evaluated by means of photographs or video:

- . size and persistence of dust cloud,
- . extent to which it masks the vehicle.

d. Note the following:

- . speed of the vehicle,
- . type of ground,
- . state of ground,
- . temperature,
- . humidity,
- . wind speed,
- . direction of wind,
- . direction of vehicle.

5. DATA REQUIRED

- a. Atmospheric conditions.
- b. Ambient temperature.
- c. Atmospheric pressure.
- d. Humidity.
- e. Time of detection for a given distance.
- f. Time of recognition for a given distance.
- g. Time of identification for a given distance.
- h. Number of detection errors for a given distance.
- i. Number of recognition errors for a given distance.
- j. Number of identification errors for a given distance.
- k. Simulated detection distances.
- l. Special features.
- m. Smoke density.

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- n. Speed of vehicle.
- o. Type of ground.
- p. State of ground.
- q. Wind speed.
- r. Direction of wind.
- s. Direction of vehicle.
- t. Description of observers.
- u. Photographic characteristics (focal distance...).
- v. Visibility distance.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

6.1 DETECTION IN DAYLIGHT

- a. Percentage of detection in relation to time of observation over all distances.
- b. Average detection distance for a significant detection percentage.
- c. Detection percentage in relation to distance.
- d. Percentage of detection errors in relation to distance.
- e. Special features leading to detection of the target.

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6.2 DETECTION AT NIGHT

- a. Percentage of detection in relation to time of observation over all distances.
- b. Average detection distance for a significant detection percentage.
- c. Detection percentage in relation to distance.
- d. Percentage of detection errors in relation to distance.
- e. Special features leading to detection of the target.

6.3 EXHAUST EFFECTS

- a. Flame emission.
- b. Smoke emission.
- c. Icy fog.

6.4 DUST CLOUD

Evaluation of size of dust cloud in relation to trial parameters.

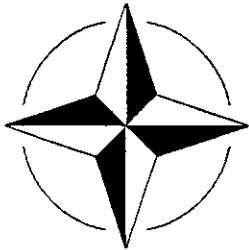
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ANNEX A: REFERENCE GRID

| | A | B | C | D | E | |
|---|---|---|---|---|---|---|
| 1 | | | | | | 1 |
| 2 | | | | | | 2 |
| 3 | | | | | | 3 |
| 4 | | | | | | 4 |
| 5 | | | | | | 5 |
| | A | B | C | D | E | |

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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : HOT SURFACES/THERMAL INFRA-RED

REFERENCE : STANAG 4357
STANAG 4358
STANAG 4319
STANAG 4349

EQUIVALENT : WEU 4FT6 NO.: TM 05-20

FOR COMPLIANCE
WITH : -

ABSTRACT : This AVTP describes a method of
measuring the radiation of a vehi-
cle in the thermal range.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: SECURITY FROM DETECTION

Test Title : HOT SURFACES/THERMAL INFRA-RED

Test No. 1 : Overall Thermal Radiation Intensity

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Test Vehicle
- 3.2 Warming up of Vehicle
- 3.3 Environment
- 3.4 Thermal Stability
- 3.5 Field of Measurement
- 3.6 Black Bodies
4. TEST PROCEDURE
5. DATA REQUIRED
6. PRESENTATION OF DATA

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Trials Series: SECURITY FROM DETECTION

Test Title : HOT SURFACES/THERMAL INFRA-RED

Test No. 2 : Thermal Detection

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Test Site
- 3.2 Test Vehicles
- 3.3 Observatiers
- 3.4 Movements and Presentation of Vehicles
4. TEST PROCEDURE
5. DATA REQUIRED
6. PRESENTATION OF DATA

ANNEX A: Overall thermal radiation intensity - Test data record

ANNEX B: Definitions

ANNEX C: Protection from thermal detection - Test data record

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Test No. 1: Overall Thermal Radiation Intensity

1. SCOPE

a. The measurement of overall thermal radiation determines the energy level projected to a sensor for a given target position. This radiation makes it possible to detect vehicles at great distances, using IR sensors, particularly those used on thermal cameras and missile heat seekers.

b. The test aims at measuring the overall radiation given off from a vehicle to a point moving round a circle, the centre of which is the vehicle.

c. These standard trials are written so as to be comparable and are based on average conditions.

2. FACILITIES AND INSTRUMENTATION

2.1 FACILITIES

Turning or positioning platform.

2.2 Instrumentation

| <u>DEVICES FOR MEASUREMENT OF:</u> | <u>UNIT</u> | <u>PERMISSIBLE ERROR OF MEASUREMENT*</u> |
|---|-------------|---|
| a. Energy radiated in wave-band II (3-5 μ m) | W/sr | variable, depending on targets |
| b. Energy radiated in wave-band III (8-12 μ m) | W/sr | |
| c. Ambient temperature | | 0.1 °C |
| d. Time | min | 1 min |
| e. IR transmission | | 5 % |
| f. Visibility | km | 5 % from 50 m to 2 km 10 % from 2 to 20 km |

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| | | |
|---|------------------|--------------------------------------|
| g. Atmospheric pressure | hPa | 2 hPa |
| h. Relative humidity or dew point | °C | 3 % of full scale |
| i. Wind speed | m/s | 0.5 m/s |
| j. Wind direction | ° | 2° |
| k. Solar radiation (daytime only) | W/m ² | 20 W/m ² |
| l. Reflected solar radiation | W/m ² | 20 W/m ² |
| m. Surface temperature | °C | 4 % |
| n. Apparent temperature of background sky (nocturnal measurement) | °C | 5 °C |
| o. Black body | °C | ≤ 2 °C of the stipulated temperature |

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

The vehicle must be dry and free of dust and mud. At night it will be kept outside and in the shade during daylight hours for at least 6 hours before the test.

3.2 Warming up of the Vehicle

The thermal state of the vehicle must be stabilised and replicable for measurements to be meaningful. A standardised warming up procedure should, therefore, be used on hard surface (cement, asphalt):

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- Drive on test track for 30 min. clockwise and 30 min. anti-clockwise.
- Speed: Approximately one-third of maximum stabilised in the highest gear. Record engine and vehicle speed.
- An additional 5 minutes in-transit time is allowed to move vehicle from warm-up area to measurement area.

3.3 Environment

Until all measurements have been taken, the environmental conditions must remain stable. The background must be uniform and stable, and represent real operational conditions. Measurements will preferably be taken at night.

3.4 Thermal Stability

In order to obtain valid measurements, they should be taken at a time when the vehicle's thermal state is in equilibrium, i.e. after approximately 15 min. idling following warming up.

3.5 Field of Measurement

The distance at which the measuring device is set up shall be such that the largest dimension of the vehicle is as close as possible to the diameter of the field of vision, but without exceeding it.

3.6 Black Bodies

Wherever possible, the black body (bodies), if required, will be installed at the same distance from the camera as the target and, preferably, in the field of measurement at the same time as the target.

The size of each black body used should be such that, when viewed by the measuring device, its projected area is significantly greater than the Instantaneous Field of View (IFOV) of the measuring device.

The temperatures of the black bodies must be within 2 °C of the stipulated temperatures.

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4. TEST PROCEDURE

- a. Measure test vehicle in "cold condition".
- b. Warm up test vehicle.
- c. Place vehicle on turning platform with engine idling.
- d. Note vehicle position.
- e. Wait for 15 min., with engine idling, before starting measurements.
- f. Record data.
- g. Move platform 15° and repeat measurements every 15° until either the circle has been completed or there has been a noticeable change in test conditions.
- h. In each position, re-set the measurements with those taken using the black bodies.
- i. If the test conditions change perceptibly, repeat from a., taking the measurements from the last position used.
- j. Collect measurements in section 4.g at 0, 20 and 60° depression angles as a minimum.

5. DATA REQUIRED

Essential measurements are:

- a. Distance from target to sensor.
- b. Energy radiated in wave-band II.
- c. Energy radiated in wave-band III.
- d. Ambient temperature.
- e. Relative humidity (or dew point).
- f. Atmospheric pressure.
- g. Visibility.

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- h. Apparent temperature of background sky.
- i. Solar radiation (daytime only).
- j. Wind speed.
- k. Wind direction.
- l. Nebulosity.
- m. Surface temperatures of:
 - 1. Tyre tread,
 - 2. Top of bonnet,
 - 3. Wheel axles,
 - 4. Body,
 - 5. Exhaust pipe.
- n. Reflected solar radiation measured at vehicle.
- o. Atmospheric Transmission in both wave-bands.

For a model test data record giving the main descriptive elements of the test, see Annex A.

6. PRESENTATION OF DATA

- a. 360° radiation diagram
- b. Table of environmental conditions, collected in a test data record (see Annex A).
- c. For each test, give full description of measuring devices used, in particular:
 - . reference and type of device
 - . main performances
 - . calibration and calibration techniques
 - . complete characteristics of sensor and signal processing electronics, e.g. IFOV, MTF, etc.

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Test No 2: Thermal Detection

1. SCOPE

a. A vehicle's detection depends on the difficulty of acquiring it as a target in an operational context. The acquisition process is made up of three distinct phases; these are, in chronological order: Detection, Recognition and Identification. There is a distance corresponding to each phase (for definition, see Annex B).

b. The text consists of a large number of observations taken, on the actual site, using a militarised IR camera. For each observation, the distance corresponding to each phase is noted, together with any errors of information. Several moving vehicles are required for recognition and identification purposes. This test can be carried out both by day and by night.

c. An evaluation can be made of the probability of detecting, recognising and identifying a vehicle at a given distance from a statistical analysis of the results.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

- | | | |
|----------------------------------|---|--------|
| - Test site |) | |
| |) | |
| - Vehicles of difference classes |) | Target |
| (tank, wheeled vehicles, etc.) |) | |
| |) | |
| - Vehicles of the same class |) | |

2.2 Instrumentation

- Militarised IR camera

DEVICES FOR MEASUREMENT OF:

PERMISSIBLE ERROR OF MEASUREMENT*

- | | |
|---------------|-------------------------|
| a. Distance | 10 m |
| b. Visibility | 5 % from 50 m to 2 km |
| | 10 % from 2 km to 20 km |

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- c. Relative humidity 3 %
- d. Ambient temperature 1 °C

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Site

It should be possible, on the site, to make horizontal observations beyond the camera's range. Successive tests can be carried out at different sites.

3.2 Vehicles

a. Test vehicles

The vehicles must be free of dust and mud. At night they will be kept outside and in the shade in daytime for at least 6 hours before the test.

b. Warming up of vehicles

The thermal state of the vehicles must be stabilised and replicable for measurements to be meaningful. A standardised warming up procedure should, therefore be used:

- Drive on test track for 30 min. clockwise and 30 min. anti-clockwise.

Speed: Approximately one-third of maximum stabilised in the highest gear. Record the speed of engine and speed of vehicle.

3.3 Observers

a. In order to obtain a realistic sample, there should be at least 10 observers.

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b. They must not be able to communicate with one another during the test.

c. Observers must know how to handle the cameras and have a good knowledge of the thermal signature of the moving vehicles.

3.4 Movements and Presentation of Vehicles

The vehicles must move 3/4 forward along a course chosen at random. So as to take account of any thermal asymmetry of one or more of the test vehicles, they should alternate between 3/4 forward, right and 3/4 forward, left.

The order in which the vehicles appear on the scene must be random, and the point of departure beyond the camera's maximum range.

4. TEST PROCEDURE

a. Warm up vehicles.

b. Drive the vehicles in close order in an area not more than 10 times the camera's field of vision (the largest if several fields are commutable).

c. Take range of moving vehicle for each phase noted (Detection, Recognition, Identification).

d. After Identification phase, bring vehicle back to starting point.

e. Change of observer.

f. Repeat test from b.

g. Each observer, having carried out an observation, repeats the sequence with a different vehicle. The same test can be carried out in other sections, using the same method.

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5. DATA REQUIRED

- a. Detection distance.
- b. Recognition distance.
- c. Identification distance.
- d. Visibility.
- e. Ambient temperature.
- f. Relative humidity of dew point.
- g. Date and hour of observation.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

- a. % Detection per distance.
- b. % Recognition per distance.
- c. % Identification per distance.
- d. Table of environmental conditions given in the test data record (see Annex C).
- e. For each test, give full description of measuring devices used, in particular:
 - reference and type of device,
 - main performances,
 - calibration.
- f. Three dimensional histogram of radiance, displaying radiant intensity of z-axis (optional).
- g. Correlation of data will be determined by means of a modified T-test (optional).

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ANNEX A: Overall thermal radiation intensity
 Test data record

| | |
|-------------------------------|--------------------------------|
| Vehicle | Date of test: Hour - Minute |
| Class: Identification No.: | Start: Finish: |

| Environmental Conditions | |
|--------------------------------|---------------------------|
| Place: | Ambient temperature: |
| Distance target/sensor: | Relative humidity: |
| Description of background: | Atmospheric pressure: |
| Description of sky: | Visibility: |
| State of vehicle: | Apparent sky temperature: |
| Dry <input type="checkbox"/> | Solar radiation: |
| Clean <input type="checkbox"/> | Wind speed: |
| Dusty <input type="checkbox"/> | Wind direction: |
| Muddy <input type="checkbox"/> | Nebulosity: |

| True Temperatures Radiant Intensity of Blackbody (Bodies) in Waveband | | | |
|--|-------------------------------------|-----------------------------------|--|
| 1 Tyre tread <input type="text"/> | 4 Wheel hub <input type="text"/> | | |
| 2 On bonnet <input type="text"/> | 5 Exhaust pipe <input type="text"/> | | |
| 3 Body work <input type="text"/> | Black Body 1 <input type="text"/> | Black Body 2 <input type="text"/> | |

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ANNEX B: Definitions

Detection Distance

Distance at which there is an indication of a target of potential military interest.

Recognition Distance

Distance at which a difference can be seen between different classes of targets and objects (e.g. a tank can be distinguished from a troop carrier).

Identification Distance

Distance at which a target of a given class can be positively identified.

True Temperature

Temperature of the object under consideration measured with a probe.

Apparent Black Body Temperature (T_a black body)

Temperature of a black body which, when placed in the sensor's field, give the same result as an object in the same wave-band.

Equivalent Black Body Temperature (T_{eq} black body)

Apparent temperature corrected for atmospheric transmission
 T_{eq} (black body) $\geq T_a$ (black body)

Instantaneous Field of View (IFOV)

The instantaneous angle of view of a single detector element at the entrance pupil of the infrared optical system.

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ANNEX C: Protection from thermal detection
Test data record

| | |
|---|---|
| Identification No.: | Date of test: Hour - Minute |
| Place of test: | Start: Finish: |
| Environmental Conditions | |
| Description of background: Description of sky: | Ambient temperature: Relative humidity: Visibility: |

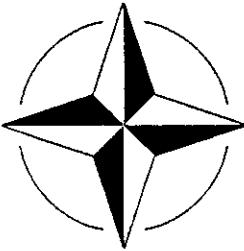
Recognition

| Test Sequence | Detection Distance | Number of Detection Errors | Recognition Distance | Number of Recognition Errors | Identification Distance | Number of Identification Errors | Vehicle Type | Vehicle Identification No. |
|---------------|--------------------|----------------------------|----------------------|------------------------------|-------------------------|---------------------------------|--------------|----------------------------|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 20 | | | | | | | | |

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AVTP : 05-30
EDITION NO.: FINAL
DATE : SEP. 1991



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : MEASUREMENT OF THE RADAR
CROSS SECTION

REFERENCE : STANAG 4357
STANAG 4358
STANAG 4234
STANAG 4316

EQUIVALENT : WEU 4FT6 NO.: TM 05-30

FOR COMPLIANCE
WITH : -

ABSTRACT : This AVTP describes the method for
measuring the Radar Cross Section
of a vehicle.

AVTP : 05-30
EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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6. Any ratifying nation may issue supplemental testing information to amplify or clarify these procedures, but in no case will such information contravene the provisions of this AVTP. If a ratifying nation must deviate from a provision of this AVTP due to constraints such as available facilities, national regulations, instrumentation accuracies, etc., the test methods used will be described in the report. However, such deviation may cause nonacceptance of test data by other nations.

FOR THE MILITARY AGENCY OF STANDARDIZATION

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*) See Reservations Overleaf

AVTP : 05-30
EDITION NO.: FINAL
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Trial Series: SECURITY FROM DETECTION

Test Title : MEASUREMENT OF THE RADAR CROSS SECTION

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Measuring Instruments
3. REQUIRED TEST CONDITIONS
- 3.1 Vehicle to be measured
- 3.2 Measurement Site
- 3.3 Instrumentation
4. TEST PROCEDURE
- 4.1 Adjusting the Instrumentation
- 4.2 Preliminary Measurements
- 4.3 Setting the Target in Place
- 4.4 Measurement
5. DATA REQUIRED
6. PRESENTATION OF DATA

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1. SCOPE

Target detection by radar is based on the property of physical objects to partially reflect incident electromagnetic waves. This property is represented by a value called the Radar Cross Section (RCS). It corresponds to the surface of the equivalent isotropic reflector and is expressed in m^2 .

The test in question consists of measuring the Radar Cross Section (RCS) of a vehicle with respect to the direction of observation. The frequency and polarisation of the electromagnetic wave are the main measurement parameters.

The overall RCS is only one of the parameters which determine whether a target can be detected; as far as possible, information should be collected on the position and nature of the scattering centres.

A target's scattering cross section depends on the direction of the incident energy as well as the direction of the scattered energy. When the two directions coincide, the scattering cross section is called monostatic or radar cross section. When the two directions are different the result is referred to as the bistatic cross section.

2. FACILITIES AND INSTRUMENTATION

Measurements are envisaged here on real targets. Measurements on scale models can be substituted if the modelling is sufficiently realistic and geometrical model scale factors are considered, including wavelength and radar cross section scaling.

2.1 Facilities

The test facility shall consist of a turning platform or a positioner and a tower capable of holding measuring instruments at varying heights corresponding to the different observation sites.

It is desirable that when measurements are carried out at different look down angles the distance between the radar and the target remains constant, in order to facilitate comparison.

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2.2 Measuring Instruments

This consists of a transmitter/receiver set working in the desired frequency band and with the required polarisation.

The polar radiation diagram of the aerials (antennas) and the determination of the range settings make it possible to confine the measurement space to as small as possible a volume surrounding the target to be measured.

3. REQUIRED TEST CONDITIONS

3.1 Vehicle to be measured

The outside appearance of the test vehicle should represent its operational configuration. The various accessories should be in place and the aerials (antennas) deployed and connected.

In the standard configuration, the vehicle must be clean and dry with the engine stopped.

Other configurations may be measured and if this is so descriptions must be provided.

3.2 Measurement Site

Unwanted signal returns from any background obstacles such as the turntable, positioner, tower, or other objects in the environment can adversely affect the measurement unless some form of discrimination or cancellation is used. Therefore the space included in the measurement volume (turning platform and immediate environment) must have the smallest possible residual Radar Cross Section. In all cases it should be 15 dB less than the target to be measured in order to provide the condition of free space. Absorbent (anechoic) material and deflectors should be used if required to obtain in this result.

3.3 Instrumentation

After setting up the measuring instruments, one must ensure that the field of illumination (amplitude and phase) is less than 3 dB (forward and return movement) with respect to the dimensions of the target.

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4. TEST PROCEDURE

4.1 Adjusting the Instrumentation

The measuring instrument must have a stable operating temperature before the tests begin. The dynamics and the sensitivity are then adjusted with respect to the target to be measured.

4.2 Preliminary Measurements

The scattered power from the target under test is given by:

$$P_r = \frac{P_t G_t G_r L^2 \sigma}{(4\pi)^3 R_t^2 R_r^2}$$

where $P(r)$ is the received power, $P(t)$ is the transmitted power, $G(t)$ is the transmitting antenna gain, $G(r)$ is the receiving antenna gain, L is the wavelength, σ is the target scattering cross section, and the R 's represent the transmit and receive distances with respect to the target.

It is conceivable that with a calibrated radar then σ could be measured by solving the above equation. However, this method is not feasible since the calibration requirement is too stringent.

The accepted method for determining σ involves comparing the power scattered from the test item with the power scattered from a calibration target used to replace the test item. The ratio equation below then provides the solution:

$$\frac{P(\text{target})}{P(\text{calibration})} = \frac{\sigma(\text{target})}{\sigma(\text{calibration})}$$

The metallic sphere is one of the most common cross section standards used (when the radius of the sphere is much larger than the wavelength) since alignment on the test stand is not so critical. Other objects such as flat

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plates, dihedrals, and trihedrals can also be used for calibration targets. The calibration selected depends upon the accuracy required and upon the scattering cross section of the test item.

A measurement of the empty platform, rotated through 360 °, enables the level of the residual radar cross section to be quantified.

A calibrator (sphere, trihedral, dihedral, etc.) is substituted for the target in order to calibrate the setup.

4.3 Setting the Target in Place

The vehicle is placed in the centre of the platform and its bearing position is noted. The value 0° is given to the position where the front of the vehicle is oriented towards the measuring instruments. The bearing 90° corresponds to the right side to the vehicle.

4.4 Measurement

The value of the radar cross section is recorded for a 360° rotation of the platform with a sampling angle of 0.1° maximum.

5. DATA REQUIRED

a. Level of RCS.

- . residual RCS of the platform
- . overall RCS of the vehicle

b. Measurement frequency

c. Transmission polarisation

d. Reception polarisation

e. Measurement geometry

- . Measurement distance (target - radar)
- . Azimuth angle

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- f. Angular increment
- g. Information on the scattering points or hot spots
(if available)
- h. Angle of polarisation
- i. Photographs of the target
 - . front view
 - . right side view
 - . rear view
 - . left side view
 - . top view

6. PRESENTATION OF DATA

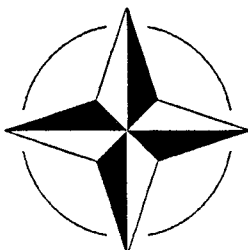
Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

- a. Polar diagram of the RCS over 360°. The data may be averaged by step of 1 degree, if required.
- b. Presentation of the main statistical results (average, median, maximum and minimum standard error, histograms).
- c. Table bringing together the measurement information mentioned in the preceeding paragraph.

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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : RADAR

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 05-30 B

FOR COMPLIANCE
WITH : -

ABSTRACT : This AVTP describes a method of
quantifying the detectability of a
vehicle using a pulse Doppler ra-
dar.

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DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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DATE : SEP. 1991

Trial Series: SECURITY FROM DETECTION

Test Title : RADAR

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Vehicles
- 3.2 Test Sites
- 3.3 Distances
- 3.4 Weather Conditions
- 3.5 Special Conditions
- 3.6 Vehicle Movement and Presentation
4. TEST PROCEDURE
- 4.1 Principle
- 4.2 Radar Methodology
5. DATA REQUIRED
6. PRESENTATION OF DATA

ANNEX A: Surveillance Areas

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DATE : SEP. 1991

1. SCOPE

This document describes a method of quantifying the detectability of the test vehicle, in comparison with a reference vehicle, using a pulse Doppler radar.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Test site enabling optical visibility observations to be made at distances corresponding to the radar range limits.

b. Reference vehicle

2.2 Instrumentation

a. Doppler radar.

b. Recording equipment.

- . for the signal from the A-scope
- . for the frequencies of the Doppler signal

c. Miscellaneous

- . Radio communication equipment.

3. REQUIRED TEST CONDITIONS

3.1 Vehicles

The vehicles' external shape should be production build standard in an as new condition, with all external items installed.

3.2 Test Site

a. The operational area of the target must allow for straight or circular vehicle paths within a minimum area of 1 km².

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b. The radar should be positioned at distances between that of certain detection and the limit of detection.

REMARK: This variation can be simulated, if this is possible, by changing the output power of the radar.

3.3 Weather Conditions

Tests must be conducted when there are no unfavourable weather conditions for the radar such as heavy rain.

3.4 Special Conditions

No vehicle other than that to be used in the tests will be allowed on the relevant area of the test site.

3.5 Vehicle Movements and Presentation

Vehicles will be driven so as to present:

- a. a 3/4 front left or right view
- b. a 3/4 rear left or right view
- c. a front view
- d. a rear view.

4. TEST PROCEDURE

4.1 Principle

In this test the radar is observing a moving a target. Unlike the case with static radar cross section (RCS) measurements, the moving target can cause several effects including the Doppler shift of the transmitted frequency. The Doppler shift does not alter the radar cross section but requires that the scattered signal be processed properly.

Another important effect is the change of aspect angle with time which can cause a very large change in the radar cross section. Statistical analysis is therefore required for analysis of dynamic cross section measurements.

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The procedure here requires that the test vehicle and the reference vehicle move successively, at the same speed, in the same direction and on the same stretch of track in direct sight and at the maximum range of the radar.

4.2 Radar Methodology

a. For each type of movement, the trials will be carried out successively according to the two kinds of radar functioning:

- No. 1: Surveillance of a circular sector over a depth of 20 km from 10 km to 30 km (See ANNEX A, Figure 1).

- No. 2: Concentrated surveillance of an area, the depth of which is reduced to 2.5 km and the origin of which can be adjusted from 0 to 28 km (See ANNEX A, Figure 2).

These parameters will be adapted to the equipment used.

b. The working parameters of the radar will be kept constant during the phases of comparative measurements (Polarisation, gain, etc.).

5. DATA REQUIRED

a. The number of echoes displayed with respect to the number of sweeps for each type of movement; the number of elementary measurements should be large enough to be statistically significant.

b. The recording of the Doppler signal detected by the radar.

c. The recording of the video signal.

d. The characteristics of the radar used.

e. Terrain description (map, photos...).

f. Description of the reference vehicle.

g. Description of the vehicle to be evaluated.

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6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

- a. Table showing the ratio between the number of echoes displayed and the number of sweeps as a function of the various parameters.
- b. An analysis of the Doppler signals indicating essential differences.

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DATE : SEP. 1991

ANNEX A: Surveillance Areas

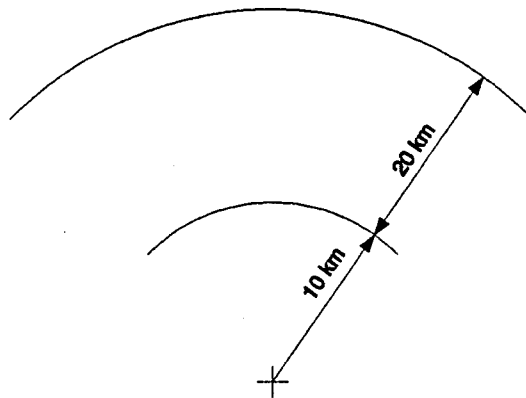


Figure 1: Surveillance Sector

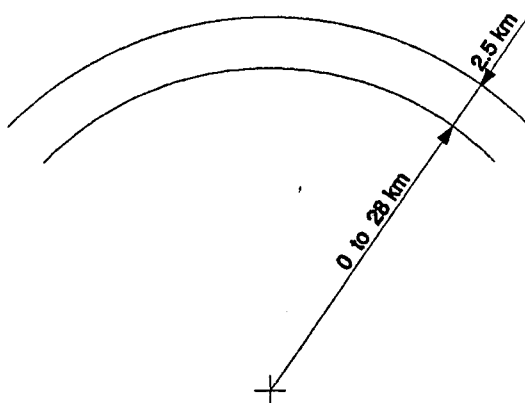
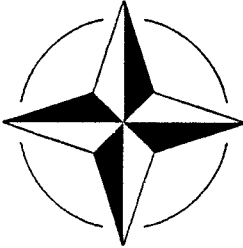


Figure 2: Concentrated Surveillance Sector

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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : MAGNETIC SIGNATURE

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT :

FOR COMPLIANCE
WITH : -

ABSTRACT : This AVTP describes a method for
acquiring the magnetic signature
of a vehicle.

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EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: SECURITY FROM DETECTION

Test Title : MAGNETIC SIGNATURE

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Test Vehicle
- 3.2 Test Site
- 3.3 Meteorological Constraints
- 3.4 Measurement Parameters
4. TEST PROCEDURE
5. DATA REQUIRED
6. PRESENTATION OF DATA

ANNEX A: Vehicle Magnetic Signature Conventions
ANNEX B: Definition of Terms
ANNEX C: Schematic Layout

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1. SCOPE

This document describes a method of acquiring the magnetic signature of a military armoured fighting vehicle. The method described will enable sufficient magnetic data to allow a vehicle's magnetic signature to be determined, without a labour intensive data gathering exercise. The number of actual magnetic measurements required to determine the entire vehicle perturbation is debatable, as certain mathematical modelling methods, including dipole synthesis, can be employed to predict the field strength and therefore reduce the number of magnetic intensity measurements required to be taken with each vehicle.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Measurement site with unpaved roadway enabling adequate space to erect sensor rigs and allow vehicle movement out to the stated maximum distance of recordings. Facilities must be available to record overhead, flank and belly magnetic data

b. Sensor rig allowing accurate positioning of magnetic sensors.

c. 3 axis magnetometer array.

d. Recording equipment and signal conditioning for the magnetometer outputs and vehicle position sensors.

e. Data logging facility for peripheral measurements, for example vehicle direction, sensor position, axis etc.

2.2 Instrumentation

DEVICES FOR
MEASUREMENT OF:

PERMISSIBLE ERROR
OF MEASUREMENT*

a. Magnetic Flux Density
 (Measurement Range $\pm 150 \mu\text{T}$)

0.1 μT

b. Digitisation resolution at least 12 Bit

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- c. Frequency Response DC-20 Hz if signatures acquired at vehicle speed and procedure stated in document.
 Digital sample rate should be five times greater than the maximum frequency required of measured value.
- d. Vehicle Speed (6-10 km/h desirable 5 %
 not essential, suits stated dynamic procedure)
- e. Sensor alignment 2 deg
- f. Vehicle Heading (Magnetic) 1 °
- g. Vehicle Dimensions 3 %
- h. Temperature 1 °C

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

NOTE: The magnetic measurements should be obtained with a magnetometer which is a speed independent device.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

The vehicle should be free of any unnecessary ferromagnetic material, where possible which is unrepresentative of a normal production sample. All external hatches should be closed, antennas removed and if a turreted vehicle, the position of the gun barrel should be noted. If ammunition is stowed within the vehicle, this should also be noted. (Normal measurements are taken with the gun barrel in a forward position parallel to the ground).

3.2 Test Site

A track capable of sustaining continual vehicle running should be made available in the directions of measurement requirement, the length of the track is commensurate with the vehicle speed for dynamic measurements. The vehicle

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should be running at a constant speed whilst in the measurement area. The track and surrounding area should be free from extensive ferromagnetic material and power cables. A slit trench, positioned across each track, enabling the acquisition of belly magnetic signatures should be available, up to 1 metre in depth, the actual sensor burial position will be dependent on measurement application and prevention of damage. The trench should desirably be co-located with the overhead and flank sensor rig.

3.3 Meteorological Constraints

The measurements are not normally dependent on specific meteorological conditions. Measurements can continue in adverse weather as long as the magnetic sensors are not disturbed by strong winds and are not affected by the ingress of water and the track way does not deteriorate.

3.4 Measurement Parameters

For dynamic measurements the magnetic signature is normally acquired when the approaching vehicle is at least 15 metres from the sensor array and is continually sampled for the next 40 metres of vehicle travel. Alternatively the sensor system can be moved to acquire the data. The data should be collected in at least two directions, orthogonal to one another, but desirable in 4 headings, i.e. the four cardinal points, north, south, east and west. To predict a vehicle's magnetic signature anywhere on the earth's surface an additional measurement should be taken at an antipodal position on the earth's surface, referenced to the point of the original measurement. This would obviously be impracticable under normal circumstances.

3.5 Sensor Parameters

Measurement spatial resolution should not be less than 0.4 metres which equates to a 0.4 metre inter-sensor distance. However, a greater resolution is desirable, for example 0.2 metres. At least two measurements at two different sensor array positions in all three axes should be made. This will enable a check on the validity of the data to be completed mathematically during analysis. This procedure applies to the overhead, both flank recordings

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and the belly measurements. Effectively, the magnetic signature will be measured around the total perimeter of a vehicle, describing a geometrical rectangle. It is important that the sensors are registered and referenced to each array position.

Regarding the array position, it is suggested that a horizontal array is deployed for the overhead and belly magnetic recordings and then replaced with a vertical array for the flank measurements. The initial measurement should be completed with the sensor array positioned as close to the target vehicle as possible without obvious risk of physical damage to the sensors. The second measurement should be made with the array displaced between 0.2 and 0.4 metres away from the original position and the measurement then repeated.

3.6 Sensor Convention

At the time of acquiring the data, any sensor convention can be used as long as the information is noted. However, it is necessary to reconstitute the data in an acceptable form when the data are analysed. Further information detailing these aspects is given in Annex A which describes the header block format for the data file structure and the desired conventions.

4. TEST PROCEDURE

- a. Assuming the dynamic vehicle method, the target vehicle should be driven at a constant speed of between 7-9 km/h, through the sensor array until the target reaches a predetermined reference, when the measurement is completed (See Annex C). Vehicle event markers are advisable (which should be recorded in conjunction with the magnetic sensor outputs), along the measurement run for reference purposes. For example, 20 metres before and 20 metres after the sensor array position plus an additional event at the sensor line. Sufficient recording lead time should be allowed at the beginning and the end of each measurement and the vehicle should reach a constant velocity before encountering the first event marker.

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- b. The nugatory distance for the measurement is defined as the amount of lateral movement of the target vehicle during the measurement run and should be no more than ± 0.1 metres, desirably less.
- c. It would be highly desirable in order to reduce experimental error if all three axes for the overhead, belly and the two flanks could be measured and recorded simultaneously. However in practice, a limit on the number of data channels and 3 axis sensors may allow only one sensor array to be used at a time. In this case the procedure is repeated for the overhead, flank and belly measurements taken in turn. The sensor gain should remain unchanged throughout each vehicle run.
- d. For measurement of the vehicle at a new heading, the sensor system is re-orientated and if necessary relocated appropriately, and the whole procedure again repeated. A desirable addition, but not essential, to the measured data would be recordings of the front and rear of each target vehicle to the same specification as the flank recordings. This would obviously require a different method of acquisition and may be time consuming but information of these areas below turret height would be beneficial to any analysis/modelling programme.

5. DATA REQUIRED

General Data

- Vehicle identification: make, type, registration number.
- Vehicle configuration: length, width, height, overall length, overall width, overall height. e.g. including main armament if fitted; turret orientation, if fitted.

Test Data

- Recorded outputs from the magnetic sensors and vehicle position indicators.
- Longitude and latitude of site.
- Sensor type, sensitivity, gain, position and convention used.

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- Measurement axis and direction (in degrees).
- Array position with reference to the vehicle under test.
- Nugatory offset with reference to the array.
- Magnetic Type indicating whether underneath, overhead or flank measurement or combination.
- Ambient or Earth's field in x, y and z planes.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

- a. Magnetic signature data stored on a suitable magnetic recording medium.
- b. Magnetic data stored as a three dimensional matrix preferably using the field array archived data format detailed in Annex A.

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ANNEX A: Vehicle Magnetic Signature Conventions

The data files are stored on an optical disk and consist of a header, defined below, and a data array. The data will be a 3 dimensional fortran real * 4 array (1:x,1:y,1:z). Values for x,y,z are contained in the header variables no_long, no_lat, no_planes, the default values for which are 200,73,30. A file could have a maximum of thirty six planes of data.

The first index defines the longitudinal direction.
The second index defines the lateral direction.
The third index defines the vertical direction.

Origin - (1,1,1): at the front left-hand corner of the lowest level of the array.

Vehicle Position:

The vehicle is aligned within the array so that: the front centre of the vehicle i.e. the mid-point of the circumscribing rectangle defined by vlength and vwidth, is situated at LONGITUDINAL index value org_long and LATERAL index value org_lat, default values for which are 75,37. The ground contact point lies minus pin_one metres removed from the lowest level within the data array.

LONGITUDINAL axis:

Horizontal, parallel to the vehicle axis, with the index increasing from front to rear of the vehicle and with magnetometer positive-going axis pointing front to rear.

LATERAL axis:

Horizontal, perpendicular to the LONGITUDINAL axis, with the index increasing from the left-hand side to the right-hand side of the vehicle (as seen by the driver, looking forwards) and with magnetometer positive-going axis pointing left to right.

VERTICAL axis:

Vertical, with the index increasing upwards and with magnetometer positive-going axis pointing upwards

Note: With the magnetometer positive-going axis lying along and in the direction of a line of force from a magnet's N-pole to its S-pole a positive signal is obtained.

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(LONGITUDINAL,LATERAL,VERTICAL) form a right-handed set.

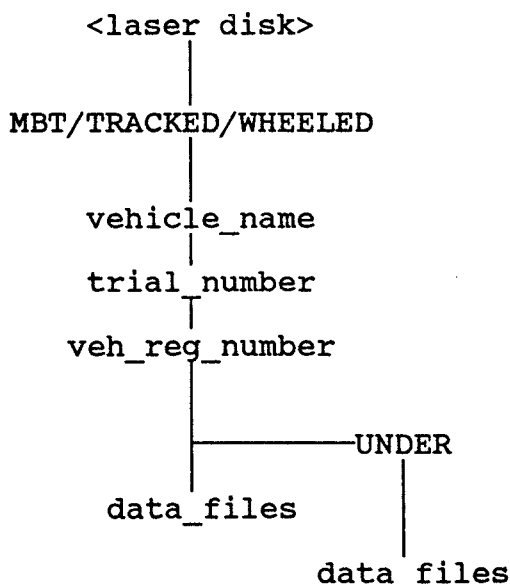
The units for the data are μ T (micro-Tesla) and have had the earth's magnetic field subtracted. Values for the ambient magnetic field are contained in lat_field, long_field, vert_field.

The data arrays are sparse; null values, i.g. unmeasured, are given the value -9999.

Each file will only contain data for one magnetic axis.

Directory Structure

The particular vehicle to which any one set of files refers is defined by the following directory structure:



Upper case indicates an actual directory name whilst lower case indicates the directory structure and the meaning of the particular field in the directory structure. e.g. veh_reg_number is the particular vehicles registration number.

The MBT directory will contain all main battle tank data, the TRACKED directory will contain all the other tracked vehicle data e.g. armoured personnel carriers and special vehicles, whilst the WHEELED directory will contain apc and ancillary wheeled vehicles.

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Data files have the following naming convention
LONGITUDINAL.nnn, LATERAL.nnn or VERTICAL.nnn
where nnn is the compass bearing in degrees of the vehicle heading.

Data files contained in the directory UNDER will only contain below ground level data, whilst data files directly under the veh_reg_number directory may contain data both above and below the vehicle. Those files which do not use the extended header format will only contain data above ground level.

File Structure

The files consist of two header blocks and the data block.

Some of the data included in the two header blocks is included to allow compatibility between different types of data so that the same search routines can access all the files.

The first data block is used by LUCID software and will not normally contain data for magnetic signature files.

Header Structure

structure /file_header/

| | | | | | |
|-----------|---|----|---------------|---|-------|
| integer | * | 4 | image_format | ! | (1) |
| integer | * | 4 | bit_precision | ! | (2) |
| integer | * | 4 | image_x_size | ! | (3) |
| integer | * | 4 | image_y_size | ! | (4) |
| integer | * | 4 | num_of_bands | ! | (5) |
| integer | * | 4 | band_list(16) | ! | (21) |
| character | * | 40 | title | ! | (31) |
| integer | * | 4 | %fill(30) | ! | (61) |
| integer | * | 4 | x_header | ! | (62) |
| integer | * | 4 | write_protect | ! | (63) |
| integer | * | 4 | %fill(193) | ! | (256) |

end structure

structure /header/

| | | | | | |
|-----------|---|----|-----------|---|-------------|
| character | * | 32 | preamble | ! | '%ARCHIVE%' |
| character | * | 1 | data_type | ! | 'I' or 'M' |
| character | * | 32 | vname | ! | veh name |
| character | * | 32 | vtype | ! | veh type |
| character | * | 32 | reg | ! | reg number |

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| | | | | | |
|-----------|------------|-----|------------------|---|--------------------|
| real | * | 4 | vheight | ! | veh height |
| real | * | 4 | vwidth | ! | veh width |
| real | * | 4 | vlength | ! | veh length |
| real | * | 4 | oheight | ! | overall height |
| real | * | 4 | owidth | ! | overall width |
| real | * | 4 | olength | ! | overall length |
| character | * | 32 | turreto | ! | turret orientation |
| character | * | 32 | site | ! | trial site |
| character | * | 32 | number | ! | trial number |
| character | * | 32 | date | ! | trial date |
| character | * | 32 | dtype | ! | data type |
| character | * | 32 | vdirection | ! | veh direction |
| character | * | 32 | sdirection | ! | sensor direction |
| character | * | 32 | latitude | ! | lat & long |
| character | * | 32 | daxis | ! | data axis |
| real | * | 4 | lat_field | ! | ambient field |
| real | * | 4 | long_field | ! | ambient field |
| real | * | 4 | vert_field | ! | ambient field |
| real | * | 4 | sfactor | ! | sensor calibration |
| integer | * | 2 | m_type | ! | Marker type |
| character | * | 32 | m_pos | ! | Marker position |
| real | * | 4 | pin-one | ! | pin 1 height |
| integer | * | 2 | no-runs | ! | Number of runs |
| character | * | 32 | series | ! | single or multiple |
| integer | * | 4 | run number | ! | 1st run number |
| character | * | 8 | extended | ! | 'EXTENDED' |
| integer | * | 4 | no_planes | ! | no of planes |
| character | * | 32 | data_qual | ! | data quality |
| real | * | 4 | long_res | ! | longitudinal res |
| integer | * | 4 | no_long | ! | no. of long. data |
| integer | * | 4 | org_long | ! | long. origin |
| real | * | 4 | lat_res | ! | lateral res |
| integer | * | 4 | no_lat | ! | no. of lat. data |
| integer | * | 4 | org_lat | ! | lateral origin |
| byte | %fill(179) | | | ! | future expansion |
| character | * | 128 | comments | ! | comments |
| real | * | 4 | plane_height(36) | ! | plane heights |

end structure

If header.extended does not contain the character string 'EXTENDED' then the data from that point onwards in the header will not be valid.

The earlier over-head data does not use the extended header and has exactly 30 planes of data where the spacing between adjacent values in all three directions is 0.2 metre.

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Later files using the extended header can have up to 36 planes at any vertical displacement, the values held in the array header.plane_height. Negative values indicating planes below ground level and a value of -9999 indicating non-valid data, these values are in metres.

The number of data points and the resolution in the other two axis is indicated by the variables no_long, long_res, no_lat, lat_res. The values contained in long_res, lat_res are in metres.

The data_qval field is used to indicate the quality of the data contained in the file. Possible values are:

EXCELLENT - all planes contain only valid data.
GOOD - a plane contains excess noise near its outer edge.
REASONABLE - some planes contain excess noise near their outer edges.
POOR - some planes contain excess noise.

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ANNEX B: Definition of Terms

1. SIGNATURE DEFINITION

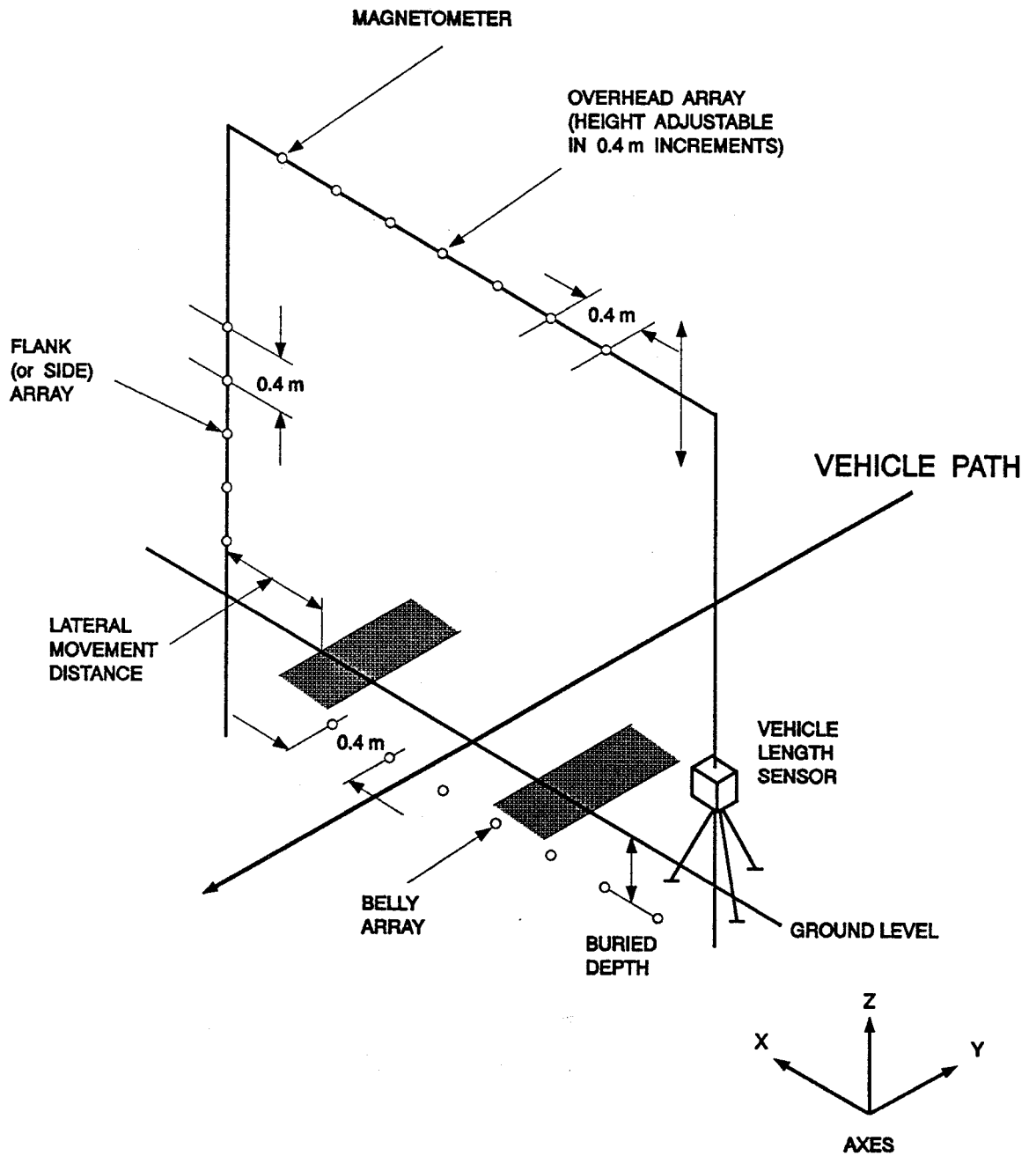
The magnetic field of a target measured by normal devices like fluxgate magnetometers is the summation of three major components:

- 1.1 Induced Field: H_i - dependent on latitude, a ferromagnetic body will distort and concentrate the "lines of force" of the local Earth's field causing a detectable perturbation. Towards the Earth's poles the affect is greater in the vertical axis, in equatorial regions the affect is greater in the horizontal axes. Therefore the position of any measured magnetic peak will depend on the latitude, (which determines the angle of Dip or Inclination), and the heading of the target.
- 1.2 Remnant Field: H_r - dependent on the permanent magnetism of a target e.g. the ferromagnetic properties due to the history of manufacture and the alignment of the domains in the material by external or internal effects, and will be dependent on the permeability and composition of the material.
- 1.3 Earth's Field: H_e - components of which exist in all three axes, X, Y, Z and is obviously dependent on latitude. A typical value for the vertical field in north west Europe is approximately 44 micro-Tesla which is comparable with the vertical anomaly field of a main battle tank, directly under the belly or in very close proximity to the turret armour, at the same latitude. This is obviously dependent on vehicle type. In a normal measurement scenario, the earth's field will be detected as a dc level and therefore will decrease the dynamic range of a sensor system. In a data acquisition exercise the earth's field should desirably be electronically "backed off".

Therefore the recorded field, H_a (a = anomaly) - $H_i + H_r$

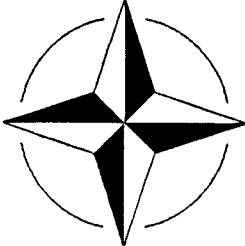
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ANNEX C: Schematic Layout



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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : SECURITY FROM DETECTION

TEST TITLE : ACOUSTIC

REFERENCE : STANAG 4357
STANAG 4358
STANAG 4318
ISO 266-1975

EQUIVALENT : WEU 4FT6 NO.: TM 05-60

FOR COMPLIANCE
WITH : -

ABSTRACT : This AVTP describes tests for conducting a series of aural detection trials.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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*) See Reservations Overleaf

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Trial Series: SECURITY FROM DETECTION

Test Title : ACOUSTIC

- Paragraph 1. SCOPE
2. FACILITIES AND INSTRUMENTATION
- 2.1 Facilities
- 2.2 Instrumentation
3. REQUIRED TEST CONDITIONS
- 3.1 Test Site
- 3.2 Environmental Conditions
- 3.3 Vehicle Condition
4. TEST PROCEDURE
- 4.1 Equipment Groups
- 4.2 Methods of Measurement
5. DATA REQUIRED
6. PRESENTATION OF DATA

ANNEX A: Site Layout for Measurements
ANNEX B: Microphone Position for Measurements
ANNEX C: Example for Data Presentation
ANNEX D: Definitions

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1. SCOPE

- 1.1 This document details the tests required for conducting a series of Security from Acoustic Detection Trials.
- 1.2 Acoustic detection of combat and support vehicles often limits their effectiveness on the battlefield. This procedure allows the range of vulnerability to acoustic detection as a function of the acoustic spectrum to be measured in a standard way.
- 1.3 An alternative method using the sense of hearing of a selected group may be employed when assessing the aural detection of a vehicle operating at a distance from a given position. This technique was produced because of the inability of sensing devices to discriminate between ambient noise and that emanating from the subject vehicle, particularly during minimum audibility investigations.
- 1.4 Reference should be made to relevant national documents and to STANAG 4318 (Acoustic Signature Requirements, Main Battle Tanks) when completing a trials plan for this procedure. Quantifiable limits of acoustic emissions are defined with consideration of variations in atmospheric propagation, background noise and auditory response.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

- a. Test Areas - various sizes and surfaces as defined in para. 4.
- b. Sound level measuring equipment complete with one-third octave filter set complying with ISO Standard 266-1975, QSTAG 447 and/or BS 5969.

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2.2 Instrumentation

| <u>DEVICES FOR MEASUREMENT OF:</u> | <u>PERMISSIBLE ERROR OF MEASUREMENT*</u> |
|--|--|
| a. Noise level | 0.5 dB |
| b. Distance | 2 % |
| c. Vehicle Speed | 5 % |
| d. Wind Speed | 5 % |
| e. Wind Direction | 50 mrad |
| f. Relative Humidity | 3 % of full scale |
| g. Ambient Temperature | 1 °C |
| h. Barometric Pressure | 1 % |

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Site

The test site must have minimum ambient noise levels and not be affected by frequent changes in ambient noise level. The test site should be remote from road, rail and aircraft routes and the ambient noise level must be at least 10 dB below the specified sound pressure in each 1/3 octave band or where no specified level exists, below the expected measured value in each octave band.

3.2 Environmental Conditions

Wind and temperature variation, change in relative humidity and precipitation may all affect measurement. Ideally, tests should be carried out over dry ground and in still air conditions. Measurements should not be taken in wind speeds greater than 6 m/s; if this cannot be avoided, tests should be repeated over different test course directions depending on the wind direction relative to the test courses.

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3.3 Vehicle Condition

The test vehicle must be prepared and equipped for normal operation or as specified in the test plan. Particular attention should be paid to the exhaust system. The tests should be conducted with the vehicle fully laden or to the loading specified in the test plan.

4. TEST PROCEDURE

4.1 Equipment Groups

- 4.1.1 All equipment should be classified into one or more groups, subject to tactical requirements and operating conditions of the equipment. These are:

Group 1 - Equipment designed for use on patrol, ambush or silent watch situations.

Group 2 - Equipment designed to be operated within a locality, where noise might provide an indication of unit location.

Group 3 - Equipment designed for use within the combat zone by units who do not expect to be in contact with enemy main force units, but who depend on concealment for protection from enemy reconnaissance units and patrols.

Group 4 - This group embraces, in general, the needs of heavy motorised equipment operating in a mobile role.

- 4.1.2 The test plan should specify the group(s) in which the equipment is required to operate.

- 4.1.3 Having specified the group for a particular item of equipment, no auxiliary equipment fitted to it should cause the resultant noise level to exceed that specified for the main equipment.

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4.2 Methods of Measurement

4.2.1 Groups 2 and 3

a. The equipment will be tested in its normal operational mode, unless stated otherwise in the test plan.

b. The site chosen shall be flat, with a uniform hard reflecting surface of concrete or smooth sealed asphalt and should extend beyond the measuring radius by at least 7.5 m. It should be free from any covering such as snow, ice or vegetation.

c. There must be no vertical reflecting surfaces within 2.5 times the measuring radius, with a minimum clear radius of 15 m.

d. It is essential that the selected site is not affected by frequent changes in ambient noise level. Ambient noise levels must be at least 10 dB below the specified sound pressure level in each 1/3 octave frequency band.

e. Equipment shall be placed at the centre of the site. The measurement distance must be more than 3 times the major dimension of the source. Assessment of equipment with a major dimension of 2 m or less shall be undertaken at 4 equidistant locations around a primary radius of 6 m as shown in ANNEX A. The most appropriate secondary radius shall be selected from the other measurement radii should the major dimension of the source exceed 2 m. All microphone heights will be 1.2 m above the ground at the appropriate measurement position.

f. The sound level meter, fitted with the 1/3-octave filter set, shall be placed in turn at each of the 4 measuring positions on the chosen radius with the microphone pointing to the plan centre.

g. Measurements with the sound level meter set at "linear" and fast meter response will be made and recorded for each of the 4 positions with:

- Equipment under test not operating, i.e. ambient noise level.

- Equipment under test operating, i.e. combined equipment and ambient noise levels.

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h. Should there be a difference of more than 5 dB between the 4 linear readings, with the equipment under test operating, further readings will be made around the chosen radius to find the maximum linear reading.

i. If there is at least 10 dB difference between sets of readings for 4.2.1.g it is assumed the effect of the ambient noise can be neglected and data required to complete the test obtained and recorded. The required one-third octave spectra, together with A-weighted and linear values are to be recorded.

j. Environmental conditions such as wind and temperature variation, change in relative humidity, precipitation, impingement of air discharge from the equipment under test and strong electric and magnetic fields, may all affect measurement; therefore precautions as stated by manufacturers in their instruction manuals for the instrumentation shall be observed.

k. Overall response of measuring equipment including wind shield, microphone, microphone preamplifier, measuring amplifier and attenuators over the frequency range 25 - 16.000 Hz shall comply with accuracy requirements and sensitivity to environmental factors as specified in relevant national or international documents. Calibrators will have an accuracy within ± 0.5 dB when compared with direct analysis.

l. Measurements should not be taken for wind speeds greater than 6 m/s and a microphone wind shield employed for wind speeds above 1 m/s. In practice, it is advisable to employ a microphone wind shield for all outdoor measurements since, to some extent, it also shields the microphone from the effects of dust and precipitation.

4.2.2 Group 1

All the test conditions stated above for groups 2 and 3 will apply to group 1 with the exception that there will be one measurement distance of 25 m and the surface will be mown grass (as found on airports and around public buildings).

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4.2.3 Group 4

a. Two maximum allowable noise emission levels are usually specified for combat vehicles. Group 4 (a) represents vehicle operation where stealth is of paramount importance and relates to an aural non-detectability distance of 500 m. Group 4 (b) represents high speed vehicle manoeuvres where mobility has high priority and relates to an aural non-detectability distance of 5000 m.

b. The test site shall be substantially level and free from vertical reflecting surfaces such as buildings or vehicles, other than the vehicle under test, for a distance of 100 m from the measurement position. The ground surface shall consist of flat mown grass free from any covering such as snow or ice.

c. Ambient noise levels must be at least 10 dB below the specified sound pressure level in each 1/3 octave band. Where equipment noise levels are not specified tests can be carried out provided the ambient noise level in each 1/3 octave band is at least 10 dB below the expected noise level to be measured. To ascertain the expected level, dummy runs should be carried out.

d. The microphone shall be located 30 m from the centreline of vehicle travel and 1.2 m above the ground plane. The microphone shall be oriented with respect to the source so that the sound strikes the diaphragm at an angle at which the microphone was designed to have flat-test frequency response over the frequency range 31.5 Hz to 10 kHz.

e. Test Procedure: The vehicle shall enter the measurement course at the chosen speed. It will maintain this speed throughout the test run with no gear changes being allowed. As the vehicle enters and traverses the measurement course the maximum (i.e. peak value) SPL in each 1/3 octave band will be recorded. The vehicle will then repeat the run from the opposite end of the measurement course without moving the microphone. This procedure should be repeated at least 5 times to establish an average peak value (calculated from the individual peak values) for each side of the vehicle in order to take account of asymmetric noise emissions. The result from the side producing the highest average SPL will be used and compared with the specified levels given at the chosen Annex C.

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f. Vehicle Speeds: The test procedure will be carried out for two constant speeds, each being representative of one of the operating modes defined in paragraph 4.2.3.a above. It is not possible to specify for all vehicles the speeds to be used since this will depend on vehicle design and configuration. Consequently, the vehicle must be operated in the following manner for each test. For the stealth mode, the vehicle shall traverse the course in the lowest forward gear. The engine speed shall be set so that the vehicle maintains a smooth constant speed for the completed course. For the high speed mode the vehicle will be driven at 2/3's of rated engine speed (not maximum governed speed) or 2/3's of posted maximum vehicle speed, in the highest gear or as otherwise specified by the manufacturer.

g. Equipment and environmental conditions shall meet the requirements defined in 4.2.1.j through 4.2.1.l.

h. Measurements will be made with the sound level meter set at "linear" and fast meter response. At least two sets of 1/3-octave readings shall be recorded for each side of the vehicle. Ambient noise levels will be recorded directly before each vehicle test run. Providing there is at least 10 dB difference between the ambient noise level and the maximum allowable level specified or the expected levels to be measured (para. 4.2.3.c), the test may proceed. The maximum vehicle noise level will be plotted by joining adjacent points with straight lines. Linear and A-weighted values will also be recorded with each set of 1/3-octave analyses.

i. Acceptable noise emission levels will depend both on operational requirements and the threat which the vehicle is designed to counter. Other levels for maximum noise emission may be proposed depending on these parameters and will be considered.

4.2.4 Subjective Test - Alternative Test

a. Jury Selection. For any subjective testing, it is necessary to select a jury of personnel representing an average cross-section of response in the particular sense required. The number of personnel comprising the jury will depend on the accuracy required. It is recommended that the jury selected should be at least ten in number and chosen from twice that number of candidates.

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Subjects will have normal hearing levels as determined by pre-test audiograms.

b. Vehicle Advancing. Establish the distance and direction at which an advancing vehicle first becomes audible to the human ear.

c. Vehicle Retiring. Establish the distance and direction at which a retiring vehicle ceases to be audible to the human ear.

d. Vehicle Crossing. Determine the directional effect of a vehicle's noise, particularly the engine noise, which can be considerably marked in the case of a tracked vehicle, or noise changes due to an asymmetrical power pack and/or transmission arrangements .

e. The above tests should be repeated a number of times, by repositioning the jury after each test, until a degree of confidence in the results can be obtained.

5. DATA REQUIRED

- a. Description of vehicle under test.
- b. Noise levels - linear, A weighted, 1/3 octave.
- c. Distance of microphone from vehicle under test.
- d. Engine speed.
- e. Vehicle speed.
- f. Source height.
- g. Microphone height.
- h. Type of surface.
- i. Subjective test results i.e. distances and opinions.
- j. Wind speed.
- k. Wind direction.
- l. Ambient temperature.

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m. Relative humidity.

n. Barometric pressure.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

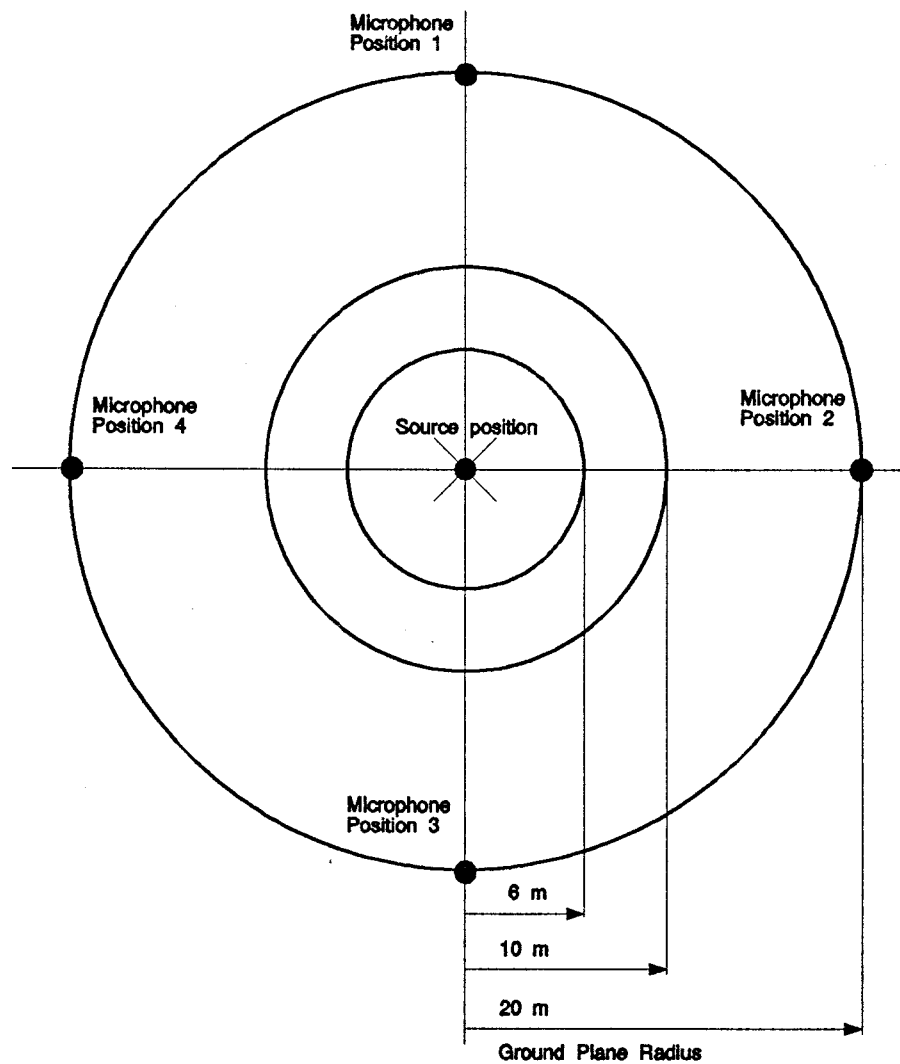
Include:

a. Graphical presentation of Sound Pressure Level (SPL) in dB versus frequency in Hz for both ambient (background) noise and vehicle under test. For example, see Annex C.

b. Other data to be tabulated with reference to the graphical presentation.

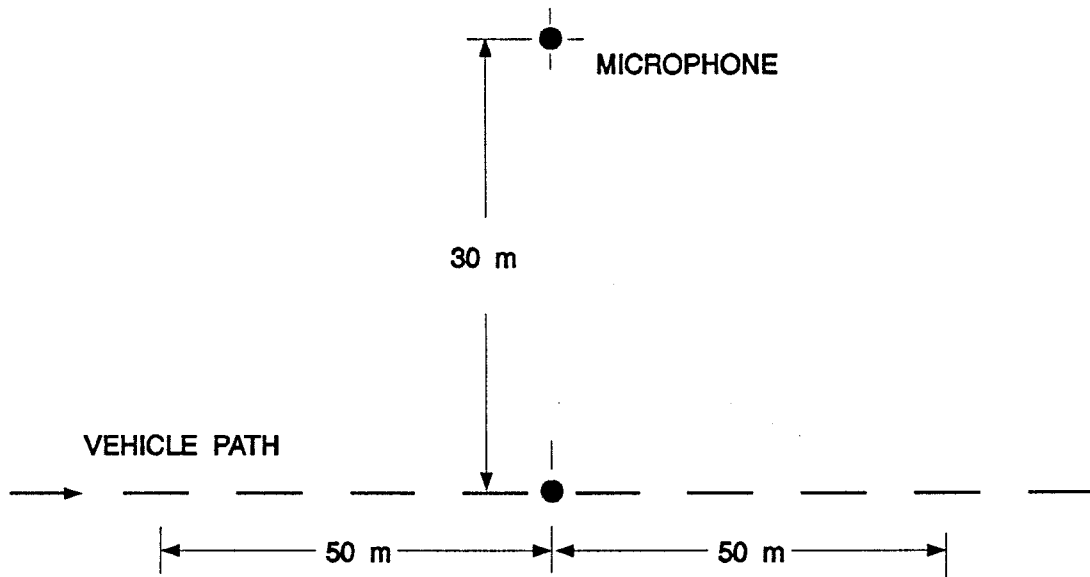
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ANNEX A: Site Layout for Measurements



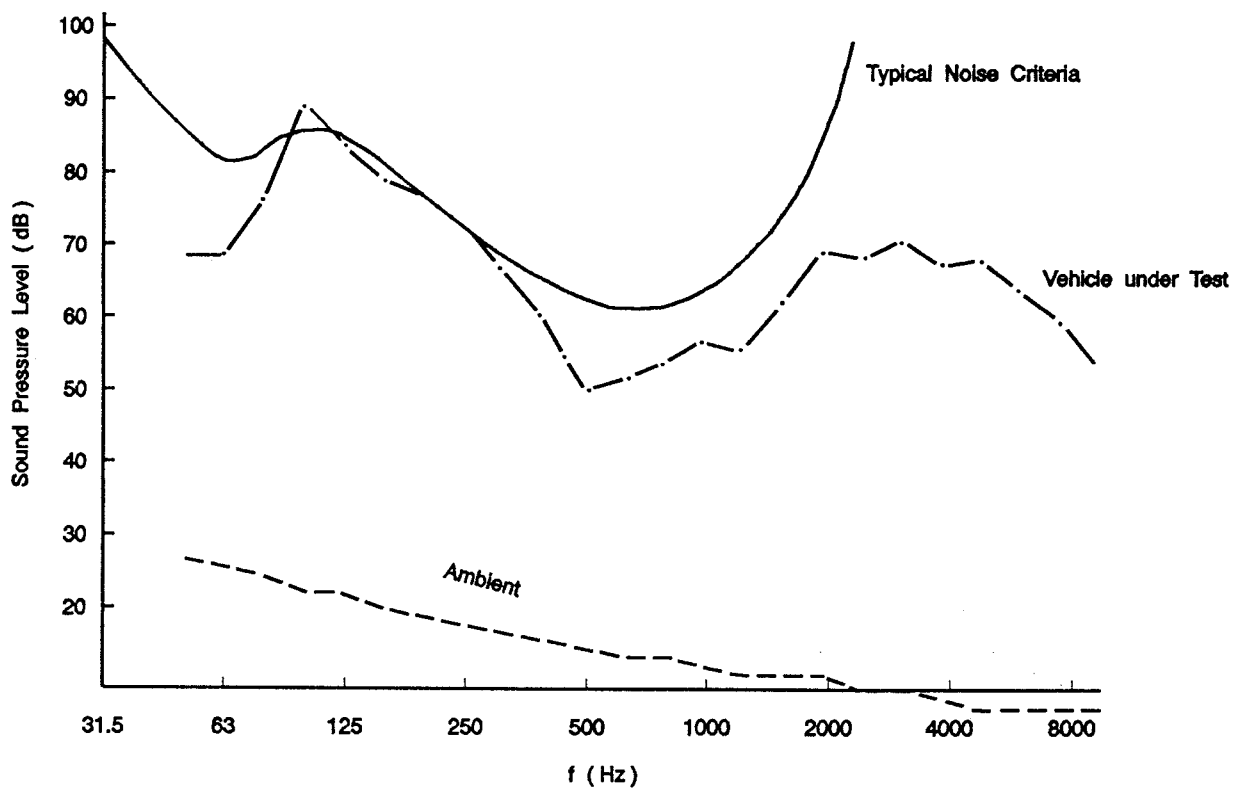
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ANNEX B: Microphone Position for Measurements



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ANNEX C: Example for Data Presentation



Test Conditions

| | | | |
|---------------------------|---------|----------------------|---------|
| Source Height: | 2.0 m | Wind Speed: | Zero |
| Detector Height: | 1.2 m | Temperature: | 12°C |
| Surface: | Grass | Relative Humidity: | 75 % |
| Vehicle Speed (Top Gear): | 30 km/h | Barometric Pressure: | 1015 mb |
| Measurement Distance: | 30 m | | |

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ANNEX D: Definitions

For the purposes of this procedure, the following definitions apply.

1. Ambient (background) noise. Any noise at the points of measurement other than that of the source being tested. It also includes the noise of any test equipment.
2. Free field. An area in which the sound propagates outwardly with essentially no effect from boundaries. In this procedure only one boundary is assumed, that of the ground reflecting surface.
3. Noise spectrum. A spectrum showing the sound pressure level distribution throughout the frequency range. The appearance of the spectrum depends upon the band width characteristics of the analysis equipment.
4. Prescribed path. The locus of a point, at the prescribed radius around the source, along which the measurement points are located.